Copy - PJH
5/28/85
c. 5

FIBROUS SLUDGE LANDSPREADING EVALUATION
BELOIT CORPORATION

C 11926

TABLE OF CONTENTS

LIST OF TABLES

PJH/nac/PJH
[nac-1-41]

FIBROUS SLUDGE LANDSPREADING EVALUATION
BELOIT CORPORATION

INTRODUCTION

The purpose of this evaluation report was two-fold. The first objective was to assess if landspreading is an acceptable and environmentally safe method for disposal of the fibrous papermill sludge generated by the Beloit Corporation. The second objective was to evaluate if the groundwater monitoring data indicates that past landspreading practices have affected groundwater quality.

The preparation of this report included a review of: analytical data and other documents describing the chemical and physical composition of the sludge; procedures used in the landspreading operation including application rate, method of incorporation and vegetative cover; location, physical characteristics and soils of the sludge receiving site; and groundwater quality data.

SLUDGE COMPOSITION

The wastewater sludge was generated during the testing of papermaking equipment by the Beloit Corporation. The sludge was discharged to three settling ponds and then dredged and stockpiled in four separate areas (Pile Nos. 1, 2, 3 and 4). Grab samples were taken from each stockpile and analyzed for the parameters shown on Table 1. The sludge in the stockpiles varied from 39 to 70 percent solids. Since the sludge solids are generated using wood pulp representative of the actual raw material processed, the chemical and physical composition of the waste is similar to that of primary papermill sludges generated by the paper industry. The major constituents of these sludges are cellulose (wood) fiber and inert paper making additives such as clay, calcium carbonate, alumina silicates with only trace amounts of heavy metals and industrially related organics. Extensive university and industry research has shown that wastewater solids generated during the pulping and papermaking processes are normally non-hazardous and that landspreading on agricultural land is an acceptable and recommended method for disposal (NCASI, 1984). The cellulose fiber is similar in composition to agricultural crop residues and can be readily broken down by microbial activity in the soil.

As indicated in Table 1, the heavy metals were found to be very low in concentration relative to an "average" municipal sewage sludge. Metals loadings to the soil from an annual application of 56 tons/acre of the Beloit Corporation sludge are only a small fraction of the annual or total cumulative life-time loadings that are allowed by state and federal landspreading criteria (State of Illinois, 1984) as shown in Table 2.

The concentrations of persistent organics in the sludge are either very low or below the level of analytical detection. An organic analysis for both volatile and base/neutral acid compounds using a gas chromatograph/mass spectra scan detected chloroform and trans-1,2 dichloroethylene in concentrations ranging from 50 to 354 ppb and <35 to 363 ppb, respectively. None of the other organics in the scan were found in detectible amounts. Once applied to the soil, these compounds are further diluted by a factor of at least 18 in the upper 6 inches of soil, and likely lost through volatilization from the soil surface, by means of biological breakdown and/or by photo-degradation processes.

LANDSPREADING OPERATIONS

The sludge has been landspread on 10.33 acres of Warsaw loam soil at an annual application rate of 56 dry tons per acre. The sludge is transferred to the receiving site by truck, distributed over the surface of the field and incorporated into the upper 6 to 10 inches of the soil by discing the same day. The field is later seeded to a perennial cover crop.

The Warsaw loam soil is well-suited to treatment/disposal of sludge and can be described as 36 inches of silt loam to silty clay loam over calcareous sand and gravel glacial outwash. The soil is well drained, relatively level (0-5 percent slope) and has moderately high available water holding capacity and cation exchange capacity. The soil has high potential productivity being well suited to the growth of corn, soybeans, small grains, grasses and legumes. With greater than 5 feet to either bedrock or the groundwater table, there is sufficient soil depth for treatment and/or attenution of sludge containing constituents.

The 56 ton/acre annual application of fibrous sludge is being landspread on idle land for the purpose of decomposing the cellulose fiber and assimulating the organic and inorganic fractions in the soil as a method of disposal and treatment. Since sludge is not being applied for the purpose of benefitting crop production and the rate of application is high relative to normal agricultural practice for returning plant residues to the soil, the 56 ton/acre application is considered a disposal rate rather than an agronomic rate of application. At this higher rate of application, sufficient nitrogen may not be available in the sludge and soil to breakdown cellulose fibers, and allow recovery of nutrient by the cover crop within the first year following application. Unless supplemental nitrogen is applied, it is recommended that only those cover crops not requiring nitrogen be sown in the first growing season following the sludge application. During the course of university research, conducted with greenhouse pot studies and field plots, this author (Huettl, 1982) demonstrated that cellulose fiber applied in a primary papermill sludge at the rate of 28.5 tons/acre/year broke down rapidly and had no measurable effect on groundwater quality. The sludge used in the study was approximately 50 percent fiber and 50 percent inorganic materials. The inorganic fraction was largely inert additives (kaolinite, TiO_2) used in making fine writing paper. The sludge was applied at the same rate for four consecutive years giving a total cummulative application of 114 tons/acre. To minimize the potential for nitrogen deficiency, the field receiving the sludge was supplemented with at least 100 pounds/acre of fertilizer nitrogen.

GROUNDWATER QUALITY

Three groundwater monitoring wells M1, M2 and M3 were previously sampled to evaluate if groundwater quality beneath the receiving site had been impacted. Monitoring Well M1 is located greater than 2,000 feet from the receiving site and based on groundwater elevation measurements, should indicate ungradient or background groundwater quality. Monitoring wells M2 and M3 are located immediately adjacent to the site, and monitoring well M3 appears to be downgradient of landspreading operations. Water samples from Wells M1, M2 and M3 were analyzed for the parameters listed in Table 3 and were found to contain slightly elevated levels of color and concentrations of 1,1-dichloroethane, 1,1,1-trichloroethane, 1,1-dichloroethylene and trichloroethylene above background and/or detection limits. Of these organics analyzed in Table 3, only the concentration of trichloroethylene exceeds the preliminary health limits for groundwater as proposed by USEPA and shown in Table 4. Elevated levels of 1,1-dichloroethane and 1,1,1-trichloroethane were found in the samples from M1 and M3, and 1,1-dichloroethene and trichloroethylene were found in the sample from M3. None of the volatile organics were found in the sample from monitoring well M2.

Most of the sludge constituents which contribute color to an aqueous solution are biodegradable or retained on soil particles and are removed within the first several inches of soil. On the receiving site there are several feet of unsaturated soil below the depth of incorporation so these constituents are not expected to reach the groundwater. As indicated in the second half of Table 4, volatile organics found in the sludge stockpiles were not found in groundwater samples. In addition, these analyses show that volatile organics found in monitoring wells were not components of the stockpiled sludge. We conclude from the available information that the chlorinated volatiles did not come from the landspreading operation. It appears that past landspreading activities have had no measurable impact on groundwater quality as monitored with Wells W1, W2 and W3.

SUMMARY

In the preceding evaluation to determine the acceptability and measurable effects of landspreading sludge, we have reviewed the data on sludge composition, groundwater quality, rate and method of application and characteristics of the receiving site. It is our opinion that the landspreading of Beloit Corporation fibrous sludge for treatment and disposal is consistent with: 1) acceptable practice for land treatment of this type of waste; 2) current state and federal regulatory criteria for landspreading; and 3) measures to provide protection of surface and groundwater quality. Compared to municipal treatment plant sludges, the Beloit Corporation sludge is relatively free of potentially toxic and/or hazardous constituents such as nitrate nitrogen, heavy metals, persistent volatile and non-volatile organic compounds, pathogenic organisms and should be readily assimilated by the soil within the period of two years or less at application rates of 28.5 to 56 tons/acre/year.

In order to hasten the breakdown of cellulose fiber in the soil and optimize the growth of the cover crop, we recommend that future sludge applications be reduced to 28.5 tons/acre/year and the soil supplemented with 100 pounds of available nitrogen.

If there are any questions on the above, or if we can be of further assistance, please do not hesitate to contact us.

Respectfully submitted,
WARZYN ENGINEERING INC.

Peter Huettl

Peter J. Huettl, Ph.D.
Senior Environmental Scientist

Roger C. Cooley

Roger C. Cooley, P.E.
Project Manager

PJH/RCC/nac/DRV
[nac-1-34]

WARZYN ENGINEERING INC

REFERENCES

1. Huettl, P.J. 1982. Disposal of a Primary Papermill Sludge on Sandy Cropland Soil. Ph.D. thesis. University of Wisconsin.

2. Illinois EPA, 1984. State of Illinois Rules and Regulations Title 35: Environmental Protection, Subtitle C: Water Pollution, Chapter II: Environmental Protection agency, Part 391: Design Criteria for Sludge Application on Land. Illinois EPA, Springfield, Illinois.

3. McCulla, T.M., J.R. Peterson and C. Lue-Hing, 1977. Properties of Agricultural and Municipal Wastes. In L.F. Elliott, Ed. Soils for Management of Organic Wastes and Waste Waters. American Society of Agronomy, Madison, Wisconsin.

4. NCASI, 1984. The Land Application and Related Utilization of Pulp and Paper Mill Sludges. National Council for Stream Imrovement, Inc., New York, Technical Bulletin No. 439.

TABLE 1

COMPOSITION OF BELOIT CORPORATION SLUDGE COMPARED TO "AVERAGE" MUNICIPAL SEWAGE SLUDGE*

Parameter	Beloit Corporation Fibrous Sludge	"Average" Municipal Sludge+
Total Volatile		
Solids, %	11.2	-
Ammonia-N, %	0.0300	0.7
Organic-N, %	0.0560	2.5
Phosphorus, %	0.0073	1.9
Chloride, mg/kg	700	NA¶
Boron, mg/kg	<0.10	109
Sulfide, mg/kg	50	NA
Metals, mg/kg		
Arsenic	0.35	43.1
Cadmium	0.76	101
Copper	14	1308
Chromium III	5.2	3280
Iron	4,400	14,000
Mercury	1.1	1077
Manganese	134	390
Nickel	10	440
Lead	11	1656
Selenium	<0.05	NA
Zinc	28	2997
Organics		
Oil & grease, %	<0.1	-
PCB's, mg/kg	<1	-
Cyanide, mg/kg	0.041	-
Phenols, mg/kg	<0.025	-
Trichlorolphenols, mg/kg	<5	-
Pentachlorophenol, mg/kg	<5	-
1,1,1-Trichloroethane, mg/kg	<0.01	-
Trichloroethylene, mg/kg	<0.01	-
Tetrachloroethylene, mg/kg	<0.01	-

* - All analyses on dry weight basis, collected 11/30/84.
¶ - NA - Not Available
+ - Mean composition for municipal sludges from 7-state area (McCalla, et al, 1977)

PJH/nac/PJH
[nac-1-27]

WARZYN
ENGINEERING INC

TABLE 2

THE LOADING OF NITROGEN AND HEAVY METALS TO THE SOIL FROM LANDSPREADING BELOIT CORPORATION FIBROUS SLUDGE

5

Parameter	Loading	Acceptable Loading Total	Acceptable Loading Annual
	pounds/acre		
Nitrogen			
Ammonia	33.0	-	*
Organic	62.0	-	*
Lead	1.23	1000	-
Manganese	14.9	900	-
Zinc	3.12	500	-
Copper	1.56	250	-
Nickel	1.11	100	-
Cadmium	0.08	10	2
Arsenic	0.40	100	-
Chromium (III)	0.53	3500	89
Mercury	0.12	-	7
Selenium	<0.0006	8	-
Silver	0.08	178	-

* Acceptable nitrogen loading to the soil depends upon potential recovery of nitrogen by the crop to be grown.

PJH-mm

PJH/ndj/PJH
[nac-1-31]

WARZYN ENGINEERING INC

TABLE 3

SUMMARY OF GROUNDWATER QUALITY AS DETERMINED WITH SAMPLES COLLECTED FROM MONITORING WELLS M1, M2 and M3 NOVEMBER 20, 1984

Parameter+

General (ppm, except pH)

pH (7.1-7.6)
TSS (22-82)
TDS (316-576)
BOD_5 (<1-2)
COD (4-8)
TOC (1.7-2.5)
Grease & Oil (2-3)

Inorganic (ppm detection)

Arsenic (0.001)
Barium (0.03-0.04)
Cadmium (0.001)
Chromium, total (<0.001-0.003)
*Color (20-50 Pt-CO units)
Copper (0.012-0.036
Lead (<0.01-0.03)
Manganese (0.014-0.114)
Mercury (<0.0001-0.0004)
Nickel (0.01)
Ammonia Nitrogen (<0.01-0.07)
Kjeldahl Nitrogen (0.17-0.61)
Phosphorus (0.01)
Selenium (0.01)
Silver (0.004-0.010)
Sulfide (2)
Zinc (<0.001-0.034)

Parameter

Volatile Organic Compounds (ppb detection)

Acrolein (<100)
Acrylonitrile (<100)
Benzene (<5)
Bromolorm (<10)
Carbon Tetrachloride (<5)
Chlorobenzene (<5)
Chlorodibromomethane (<10)
Chloroethane (<20)
Chloroethylvinyl Ether (<50)
Chloroform (<5)
Dichlorobromomethane (<5)
*1,1-Dichloroethane (8.5 in M1, 5.8 in M3)
1,2-Dichloroethane (<5)
*1,1-Dichloroethylene (6.9 in M3)
1,2-Dichloropropane (<5)
1,3-Dichloropropylene (<5)
Ethylbenzene (<5)
Methyl Bromide (<20)
Methyl Chloride (<20)
Methylene Chloride (<10)
1,1,2,2-Tetrachloroethane (<10)
Tetrachloroethylene (<5)
Toluene (<5)
Trans-1,2-Dichloroethylene (<5)
*1,1,1-Trichloroethane (9 in M1, 174 in M3)
1,1,2-Trichloroethane (<10)
*Trichloroethylene (106 in M3, <5)
Vinyl Chloride (<20)

+ Range of concentrations determined for water samples collected November 20, 1985 or detection limits when those constituents were not detected as indicated by "<" sign.

* Parameters found in elevated concentrations or organics above detection limit (See Table 2)

Samples were collected on November 20, 1985

[cac-6-39]

WARZYN ENGINEERING INC

TABLE 3 (Continued)

SUMMARY OF GROUNDWATER QUALITY
AS DETERMINED WITH SAMPLES COLLECTED FROM MONITORING
WELLS M1, M2 and M3
NOVEMBER 20, 1984

Base/Neutral Organics
(ppb detection)

Acenaphthene (<10)
Acenaphthylene (<10)
Anthracene (<10)
Benzidine (<50)
Benzo(a) Anthracene (<10)
Benzo(a) Pyrene (<10)
3,4-Benzofluorathene (<10)
Benzo(ghi) Perylene (<10)
Benzo(k) Fluorathene (<10)
Bis(2-Chloroethoxy Methane (<10)
Bis(2-Chlorothyl) Ether (<10)
Bis(2-Chloroisopropyl) Ether (<10)
Bis(2-Hylhexyl) Phthalate (<10)
4-Bromophenyl Phenyl Ether (<10)
Butyl Benzyl Phthalate (<10)
2-Chloronaphthalene (<10)
4-Chlorophenyl Phenyl Ether (<10)
Chrysene (<10)
Dibenzo (a,h) Anthracene (<10)
1,2-Dichlorobenzene (<10)
1,3-Dichlorobenzene (<10)
1,4-Dichlorobenzene (<10)
3,3-Dichlorobenzidine (<25)
Diethyl Phthalate (<10)
Dimethyl Phthalate (<10)
Di-n-Butyl Phthalate (<10)
2,4-Dinitrotoluene (<10)
2,6-Dinitrotoluene (<10)
Di-n-Octyl Phthalate (<10)
1,2-Diphenylhydrazine (as Azobenzene) (<10)

Base/Neutral Organics
(ppb detection)(cont'd)

Fluorathene (<10)
Fluorene (<10)
Hexachlorobenzene (<10)
Hexachlorobutadiene (<10)
Hexachlorocyclopentadiene (<25)
Hexachloroethane (<10)
Indeno (1,2,3-cd) Pyrene (<10)
Isophorone (<10)
Naphthalene (<10)
Nitrobenzene (<10)
N-Nitrosodi-n-Propylamine (<10)
N-Nitrosodiphenylamine (<10)
Phenanthrene (<10)
Pyrene (<10)
1,2,4-Trichlorobenzene (<10)

Acid Compounds (ppb detection)

2-Chlorophenol (<10)
2,4-Dichlorophenol (<10)
2,4-Dimethylphenol (<10)
4,6-Dinitro-O-Cresol (<10)
2,4-Dinitrophenol (<25)
2-Nitrophenol (<10)
4-Nitrophenol (<10)
P-Chloro-m-Cresol (<10)
Pentachlorophenol (<10)
Phenol (<10)
2,4,6-Trichlorophenol (<10)

PJH/nac/PJH
[cac-6-39]

WARZYN
ENGINEERING INC

TABLE 4

COMPARISON OF ORGANIC VOLATILES COMPOSITION OF SLUDGE AND WATER QUALITY AS SAMPLED IN GROUNDWATER MONITORING WELLS AND SETTLING POND

Volatile Organics

Parameter	Sludge Stock Piles #1	#2	#3	#4	Monitoring Wells Groundwater M1	M2	M3	Settling Pond	USEPA Proposed Interim Health Limits for Groundwater Quality
	ug/kg				ug/l				
Chloroform	50	66	116	354	<5	<5	<5	<5	100*
1,1-Dichloroethane	<35	<35	<35	<35	8.5	<5	5.8	<5	None
Trans-1,2-Dichloroethylene	<35	39	55	363	<5	<5	<5	<5	272+
1,1,1-Trichloroethane	<10	<10	<10	<105	9.0	<5	174	<5	1,070
1,1-Dichloroethylene	<35	<35	<35	<105	<5	<5	6.9	<5	10
Trichloroethylene	<35	<35	<35	<105	<5	<5	106	<5	45

* For total trihalomethanes

\+ 10-day recommendation only (no data for long-term exposure available)

¶ Groundwater quality limits as proposed by USEPA Office of Drinking Water and/or USEPA National Interium Primary Water Regulation

PJH/nac/PJH
[nac-1-31]

WARZYN ENGINEERING INC